General aptitude

Q. No. 1 – 5 Carry One Mark Each

1. Five teams have to compete in a league, with every team playing every other team exactly once, before going to the next round. How many matches will have to be held complete the league round of matches?

   (A) 20 (B) 10 (C) 8 (D) 5

Answer: (B)

Exp: For a match to be played, we need 2 teams

L No of matches = no. of ways of selections 2 teams out of 5

$= 5_{C_2} = 10$

2. Tanya is older than Enc.

   Cliff is older than Tanya.

   Eric is older than Cliff.

   If the first two statements are true, then the third statement is

   (A) True (B) False (C) Uncertain (D) Data insufficient

Answer: (B)

3. Choose the appropriate word/phase, out of the four options given below, to complete the following sentence:

   Apparent lifelessness ___________ dormant life.

   (A) harbours (b) lead to (c) supports (d) affects

Answer: (A)

Exp: Apparent: looks like

dormant: hidden

Harbour: give shelter

Effect (verb): results in

4. Choose the statement where underlined word is used correctly.

   (A) When the teacher eludes to different authors, he is being <u>elusive</u>

   (B) When the thief keeps eluding the police, he is being <u>elusive</u>

   (C) Matters that are difficult to understand, identify or remember are <u>allusive</u>

   (D) Mirages can be <u>allusive</u>, but a better way to express them is illusory

Answer: (B)

Exp: Elusive: Difficult to answer.

5. Fill in the blank with the correct idiom/phrase.

That boy from the town was a __________ in the sleepy village.

(A) Dog out of herd (B) Sheep from the heap

(C) Fish out of water (D) Bird from the flock

Answer: (C)

Exp: From the statement, it appears that boy found it tough to adapt to a very different situation.

Q. No. 6 – 10 Carry Two Marks Each

6. Right triangle PQR is to be constructed in the xy – plane so that the right angle is at P and line PR is parallel to the-axis. The x and y coordinates of P, Q, and R are to be integers that satisfy the inequalities: $-4 \le x \le 5$ and $6 \le y \le 16$. How many different triangles could be constructed with these properties?

(A) 110 (B) 1,100 (C) 9,900 (D) 10,000

Answer: (C)

Exp: $X_1 \to -4 \le X_1 \le 5$

$Y_1 \to 6 \le Y_1 \le 16$

$X_2 \to 9 \text{ chairs} \left(\because X_1 \ne X_2\right)$

$Y_2 \to 10 \text{ chairs} \left(\because Y_1 \ne Y_2\right)$

$\therefore \text{Total triangles} = 10 \times 11 \times 9 \times 10 = 9900$

7. Select the appropriate option in place of underlined part of the sentence.

<u>Increased productivity necessary</u> reflects greater efforts made by the employees.

(A) Increase in productivity necessary

(B) Increase productivity is necessary

(C) Increase in productivity necessarily

(D) No improvement required

Answer: (C)

8. Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows:

Statements:

I. No manager is a leader. II. All leaders are executive.

Conclusions:

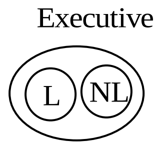
I. No manager is a executive. II. All executive is a manager.

(A) Only conclusion I follows. (B) Only conclusion II follows.

(C) Neither conclusion I nor II follows. (D) Both conclusion I and II follow.

Answer: (C)

Exp:



Therefore concluding diagram can be
It can be manager that is manager can be executive also.
Some executives are also leaders that is not a manager

9. A coin is tossed thrice. Let X be the event that head occurs in each of the first two tosses. Let Y be the event that a tail occurs on the third toss. Let Z be the event that two tails occurs in three tosses. Based on the above information, which one of the following statements is TRUE?

(A) X and Y are not independent

(B) Y and Z are dependent

(C) Y and Z are independent

(D) X and Z independent

Answer: (B)

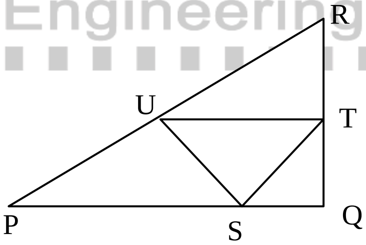
Exp: Let y as tail occurred in third toss

and z as two tails in third toss which can be {TTH, THT, HTT}

y = {TTH, TTT}

$\therefore$ both y and z are dependent.

10. In the given figure angle Q is a right angle, PS:QS = 3:1, RT:QT = 5:2 and PU:UR = 1:1. If area of triangle QTS is 20 cm^2, then the area of triangle PQR in cm^2 is ______.



Answer: 280

Exp: Let area of triangle PQR be 'A'

$$\frac{SQ}{PQ}=\frac{1}{1+3}=\frac{1}{4}$$

$$\frac{QT}{QR}=\frac{2}{2+5}=\frac{2}{7}$$

$$\therefore \text{Area of } \Delta^{le}\ QTS=\frac{1}{2}\times SQ\times QT$$

$$=\frac{1}{2}\times\left(\frac{1}{4}PQ\right)\times\left(\frac{2}{7}QR\right)$$

$$=\frac{1}{4}\times\frac{2}{7}\times\left(\frac{1}{2}\times PQ\times QR\right)$$

$$=\frac{1}{14}\times \text{Area of } \Delta^{le}\ PQR$$

$$\text{given } 20\text{cm}^2 = \frac{1}{14} \times A$$

$$\therefore A = 14 \times 20 = 280\,\text{cm}^2$$

Mechanical Engineering

Q. No. 1 – 25 Carry One Mark Each

1. Three parallel pipes connected at the two ends have flow-rates Q_1, Q_2 and Q_3 respectively, and the corresponding frictional head losses are hL_1, h_{L2} and h_{L3} respectively. The correct expressions for total flow rate (Q) and frictional head loss across the two ends (h_L) are

(A) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(B) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$
(C) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(D) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$

Answer: (B)

Exp: Total flow rate $Q = Q_1 + Q_2 + Q_3$

head loss $h = h_{L_1} = h_{L_2} = h_{L_3}$

2. The lowest eigen value of the 2 × 2 matrix $\begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$ is ________

Answer: 2

Exp: Let $A = \begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$

Characteristic equation of A is $|A - \lambda I| = 0$

$$\Rightarrow \begin{vmatrix} 4-\lambda & 2 \\ 1 & 3-\lambda \end{vmatrix} = 0$$

$$\Rightarrow \lambda^2 - 7\lambda + 10 = 0 \quad \Rightarrow \lambda = 2,5$$

3. Which two of the following joining processes are autogenous?

i. Diffusion welding
ii. Electroslag welding
iii. Tungsten inert gas welding
iv. Friction welding

(A) i and iv (B) ii and iii (C) ii and iv (D) i and iii

Answer: (A)

Exp: Diffusion welding and friction welding are autogenous welding process as they do not require any filler material.

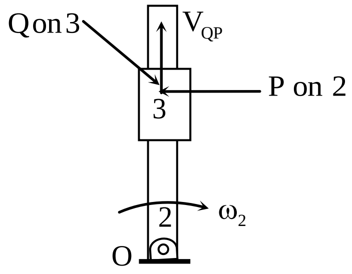
4. The strain hardening exponent n of stainless steel SS 304 with distinct yield and UTS values undergoing plastic deformation is

(A) $n < 0$ (B) $n = 0$ (C) $0 < n < 1$ (D) $n = 1$

Answer: (C)

Exp: n lies between 0 and 1. 0 means material is a perfectly plastic solid, while 1 represents a 100% elastic solid.

5. In the figure, link 2 rotates with constant angular velocity ω_2. A slider link 3 moves outwards with a constant relative velocity $V_{Q/P}$, where Q is a point on slider 3 and P is a point on link 2. The magnitude and direction of Coriolis component of acceleration is given by



(A) $2\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction ω_2

(B) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction ω_2

(C) $2\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction of ω_2

(D) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction ω_2

Answer: (A)

Exp: direction is obtained by rotating velocity vector through 90^{o} in the direction of rotation of the link.

6. Couette flow is characterized by

(A) steady, incompressible, laminar flow through a straight circular pipe

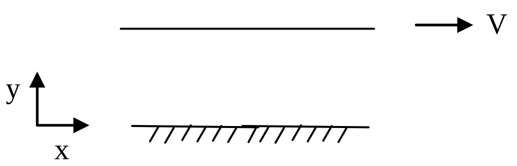
(B) fully developed turbulent flow through a straight circular pipe

(C) steady, incompressible, laminar flow between two fixed parallel plates

(D) steady, incompressible, laminar flow between one fixed plate and the other moving with a constant velocity

Answer: (D)

Exp: Coutte flow is steady incompressible, laminar flow between one fixed plate and other moving with constant velocity.



7. If $P(X) = 1/4, P(Y) = 1/3$, and $P(X \cap Y) = 1/12$, the value of $P(Y/X)$ is

(A) $\frac{1}{4}$ (B) $\frac{4}{25}$ (C) $\frac{1}{3}$ (D) $\frac{29}{50}$

Answer: (C)

Exp: $P(Y/X) = \frac{P(X \cap Y)}{P(X)} = \frac{\frac{1}{12}}{\frac{1}{4}} = \frac{1}{3}$

8. In a machining operation, if the generatrix and directix both are straight lines, the surface obtained

(A) cylindrical
(B) helical
(C) plane
(D) surface of revolution

Answer: (C)

Exp: The surface obtained is plane.

9. A rigid container of volume 0.5 m^3 contains 1.0 kg of water at 120°C (v_f = 0.00106 m^3/kg, v_g = 0.8908 m^3/kg). The state of water is

(A) Compressed liquid
(B) Saturated liquid
(C) A mixture of saturated liquid and saturated vapor
(D) Superheated vapor

Answer: (C)

Exp: $V = \frac{0.5}{1} m^3/kg = 0.5 m^3/kg$

Since $V_f < V < V_g$ the state of water is mixture of saturated water and saturated vapour.

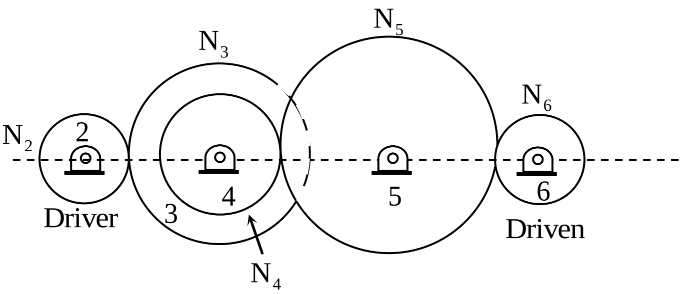
10. In full mould (cavity-less) casting process, the pattern is made of

(A) expanded polystyrene
(B) wax
(C) epoxy
(D) plaster of Paris

Answer: (A)

Exp: The pattern is made of expanded polystrene

11. A gear train is made up of five spur gears as shown in the figure. Gear 2 is driver and gear 6 is driven member. N_2, N_3, N_4, N_5 and N_6 represent number of teeth on gears 2, 3, 5 and 6 respectively. The gear(s) which act(s) as idler(s) is/are



(A) only 3
(B) only 4
(C) only 5
(D) Both 3 and 5

Answer: (C)

Exp: $\frac{\omega_2}{\omega_6} = \frac{\omega_2}{\omega_3}\frac{\omega_3}{\omega_5}\frac{\omega_5}{\omega_6} = \frac{N_3}{N_2}\frac{N_5}{N_4}\frac{N_6}{N_5} = \frac{N_3 N_6}{N_2 N_4}$

$\therefore$ only Gear(5) is Idle

12. Let ϕ be an arbitrary smooth real valued scalar function and V be an arbitrary smooth vector valued function in a three-dimensional space. Which one of the following is an identity?

(A) $\mathrm{Curl}\left(\phi\overline{V}\right) = \nabla\left(\phi \mathrm{Div}\overline{V}\right)$ (B) $\mathrm{Div}\,\overline{V} = 0$

(C) $\mathrm{Div}\,\mathrm{Curl}\,\overline{V} = 0$ (D) $\mathrm{Div}\left(\phi\overline{V}\right) = \phi\mathrm{Div}\overline{V}$

Answer: (C)

13. Which of the following statements are TRUE for damped vibrations?

P. For a system having critical damping, the value of damping ratio is unity and system does not undergo a vibratory motion.

Q. Logarithmic decrement method is used to determine the amount do damping in a physical system.

R. In case of damping due to dry friction between moving surfaces resisting force of constant magnitude acts opposite to the relative motion.

S. For the case of viscous damping, drag force is directly proportional to the square of relative velocity.

(A) P and Q only (B) P and S only

(C) P, Q and R only (D) Q and S only

Answer: (C)

14. The value of $\lim_{x\to 0}\left(\frac{-\sin x}{2\sin x + x\cos x}\right)$ is ____

Answer: -0.333

Exp: $\lim_{x\to 0}\left(\frac{-\sin x}{2\sin x + x\cos x}\right) \qquad \left(\frac{0}{0}\text{form}\right)$

$= \lim_{x\to 0}\left(\frac{-\cos x}{2\cos x + \cos x - x\sin x}\right) \qquad (\text{L} - \text{Hospital Rule})$

$= \frac{-1}{3}$

15. The ratio of momentum diffusivity (v) to thermal diffusivity (α), is called

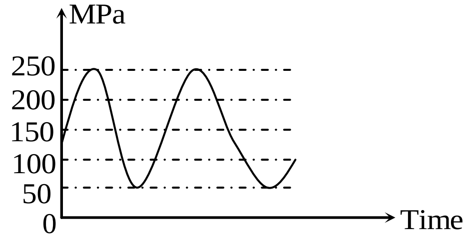
(A) Prandtl number (B) Nusselt number

(C) Biot number (D) Lewis number

Answer: (A)

Exp: $Pr = \frac{\mu C_p}{k} = \frac{\rho V C_p}{k} = \frac{V}{\frac{k}{\rho c_p}} = \frac{V}{\alpha}$

16. For the given fluctuating fatigue load, the values of stress amplitude and stress ratio are respectively



(A) 100 MPa and 5
(B) 250 MPa and 5
(C) 100 MPa and 0.20
(D) 250 MPa and 0.20

Answer: (C)

Exp: $\text{stress amplitude} = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{250-50}{2} = 100\ \text{Mpa}$

$\text{Stress ratio} = \frac{\sigma_{min}}{\sigma_{max}} = \frac{50}{250} = 0.2$

17. Using a unit step size, the value of integral $\int_1^2 x \ln x \, dx$ by trapezoidal rule is ______

Answer: 0.69

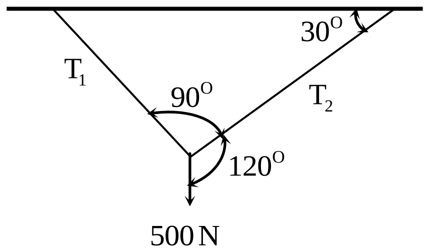
Exp:

x	1	2
y = 1hx	0	21h2

By Trapezoidal Rule,

$$\int_1^2 x1nx\ dx = \frac{1}{2}\left[0 + 21n2\right] = 1n2 = 0.69$$

18. A weight of 500 N is supported by two metallic ropes as shown in the figure. The values of tensions T_1 and T_2 are respectively



(A) 433 N and 250 N (B) 250 N and 433 N

(C) 353.5 N and 250 N (D) 250 N and 353.5 N

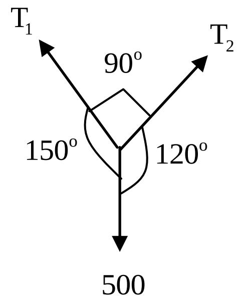
Answer: (A)

Exp: Using sine rule

$$\frac{T_1}{\sin 120^o} = \frac{T_2}{\sin 150^o} = \frac{500}{\sin 90^o}$$

$T_1 = 500 \times \sin 120^o$; $T_2 = 500 \sin 150^o$

$T_1 = 433\ N$ $T_2 = 250\ N$



19. In the notation (a/b/c) : (d/e/f) for summarizing the characteristics of queueing situation, the letters 'b' and 'd' stand respectively for

(A) service time distribution and queue discipline

(B) number of servers and size of calling source

(C) number of servers and queue discipline

(D) service time distribution and maximum number allowed in system

Answer: (A)

Exp: b: Service time distribution (usually represented by 'm')

D: Queuing discipline (usually represented by 'GD')

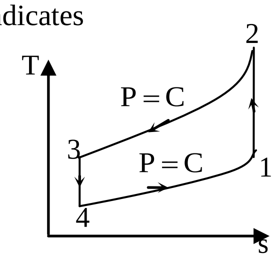
20. The thermodynamic cycle shown in figure (T/s diagram) indicates

(A) Reversed Cannot cycle

(B) Reversed Brayton cycle

(C) Vapor compression cycle

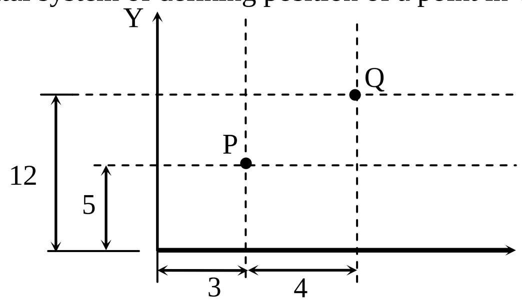
(D) Vapor absorption cycle



Answer: (B)

Exp: T-S diagram represent a reversed brayton cycle used in air conditioning of aero planes where air is used as a refrigerant.

21. A drill is positioned at point *P* and its has to proceed to point *Q*. The coordinates of point *Q* in the incremental system of defining position of a point in *CNC* part program will be



(A) (3, 12) (B) (5, 7) (C) (7, 12) (D) (4, 7)

Answer: (D)

Exp: In incremental system. Co-ordinates of point Q are (4,7).

22. A cylindrical tank with closed ends is filled with compressed air at a pressure of 500 kPa. The inner radius of the tank is 2m, and it has wall thickness of 10 mm. The magnitude of maximum in-plane shear stress (in MPa) is ____ .

Answer: 25

Exp: Maximum in-plane shear stress $\tau_{max} = \frac{pd}{8t}$

$$= \frac{500 \times 4}{8 \times 10} \text{MPa} = 25 \text{MPa}$$

23. An air-standard Diesel cycle consists of the following processes:

1-2: Air is compressed isentropically.

2-3: Heat is added at cosntant pressure.

3-4: Air expands isentropically to the original volume.

4-1: Heat is rejected at constant volume.

If γ and T denotes the specific heat ratio and temperature, respectively the efficiency of the cycle is

(A) $1 - \frac{T_4 - T_1}{T_3 - T_2}$ (B) $1 - \frac{T_4 - T_1}{\gamma(T_3 - T_2)}$

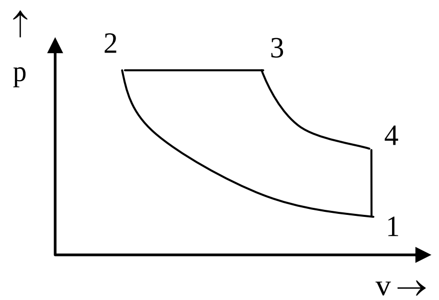
(C) $1 - \frac{\gamma(T_4 - T_1)}{T_3 - T_2}$ (D) $1 - \frac{T_4 - T_1}{(\gamma - 1)(T_3 - T_2)}$

Answer: (B)

Exp: heat applied, $Q_s = c_p(T_3 - T_2)$

heat rejected, $Q_r = c_r(T_4 - T_1)$

$$\eta = 1 - \frac{Q_r}{Q_s} = 1 - \frac{1}{\gamma}\frac{(T_4 - T_1)}{(T_3 - T_2)}$$



24. Saturated vapor is condensed to saturated liquid in condenser. The heat capacity ratio is $C_r = \frac{c_{min}}{c_{max}}$. The effectiveness (ε) of the condenser is

(A) $\frac{1 - \exp[-NTU(1 + C_r)]}{1 + C_r}$ (B) $\frac{1 - \exp[-NTU(1 - C_r)]}{1 - C_r \exp[-NTU(1 - C_r)]}$

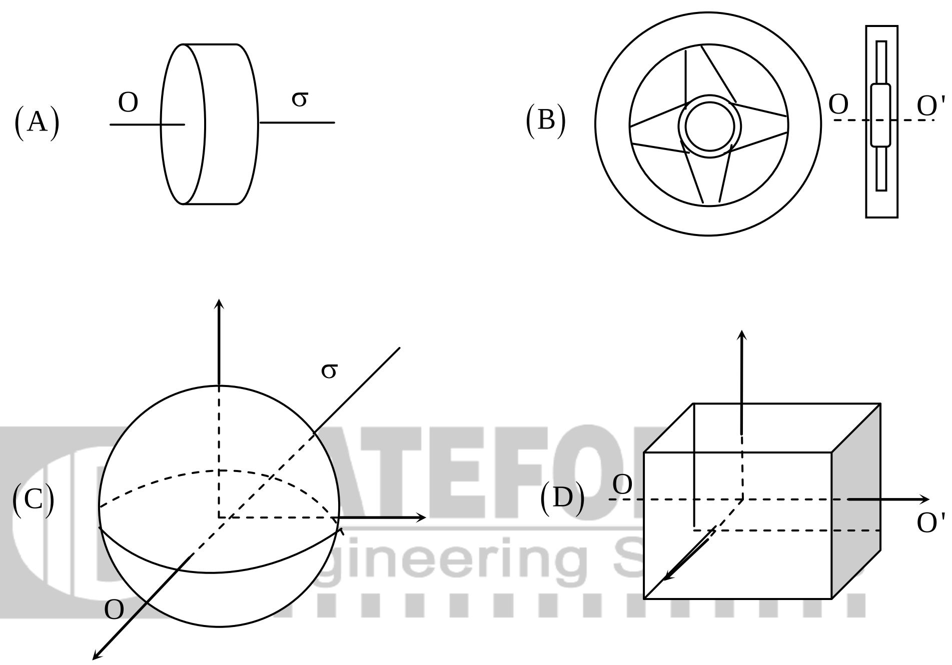
(C) $\frac{NTU}{1 + NTU}$ (D) $1 - \exp(-NTU)$

Answer: (D)

Exp: E of condenser is given by 1-exp(-NTU)

because $C_r = \frac{C_{min}}{C_{max}} = 0.$ (as $C_{max} \to \infty$)

25. For the same material and the mass, which of the following configurations of flywheel will have maximum mass moment of inertia about the axis of rotation OO' passing through the center of gravity



Answer: (B)

Exp: Rim med wheel has maximum mass located away from the axis of rotation Thus will have maximum moment of inertia.

Q. No. 26 – 55 Carry Two Marks Each

26. For ball bearings, the fatigue life L measured in number of revolutions and the radial load F are related by $FL^{1/3} = K$, where K is a constant. It withstands a radial load of 2 kN for a life of 540 million revolutions. The load (in kN) for a life of one million revolutions is ______

Answer: 16.286

Exp: $FL^{\frac{1}{3}} = k$

$$F_1 L_1^{\frac{1}{3}} = F_2 L_2^{\frac{1}{3}}$$

$$2 \times 540^{\frac{1}{3}} = F_2 (1)^{\frac{1}{3}}$$

$$\therefore F_2 = 16.286\,kN$$

27. The torque (in N-m) exerted on the crank shaft of a two stroke engine can be described as T = 10000 + 1000 sin 1θ – 1200 cos 2θ, where θ is the crank angle as measured from inner dead center position. Assuming the resisting torque to be constant, the power (in kW) developed by the engine at 100 rpm is __________.

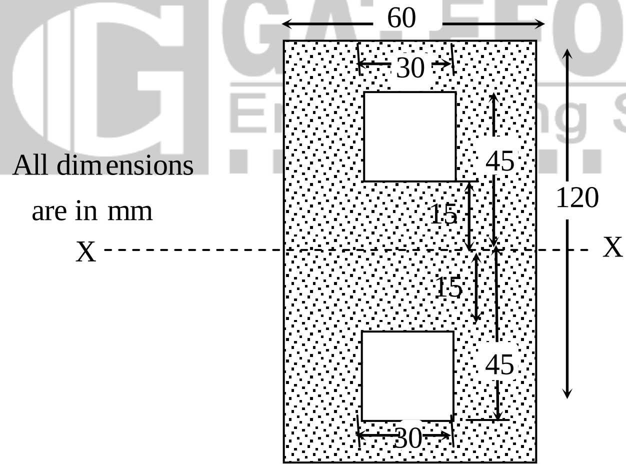
Answer: 104

Exp: $T_{mean} = 10000\,N - m$

$$\omega_{mean} = 100 \times \frac{2\pi}{60}$$

$$P = T_{mean} \times \omega_{mean} = 10^4 \times \frac{200\pi}{60} = 104\,kW$$

28. The value of moment o inertia of the section shown in the figure about the ais-XX is



(A) $8.5050 \times 10^6\,mm^4$ (B) $6.88.50 \times 10^5\,mm^4$

(C) $7.7625 \times 10^6\,mm^4$ (D) $8.5725 \times 10^6\,mm^4$

Answer: (B)

Exp: Moment of Inertia. $I_{xx} = \frac{1}{12}\left[(120)^3 \times 60\right] - 2\left[\frac{1}{12} \times (30)^4 + 30 \times 30 \times 30\right]$

$$= 6.885 \times 10^6\,mm^4$$

29. The value of

$\int_C \left[\left(3x - 8y^2\right)dx + \left(4y - 6xy\right)dy\right]$, (where C is boundary of th region bounded by x = 0, y = 0 and x + y = 1 is) is ____________

Answer: 1.66

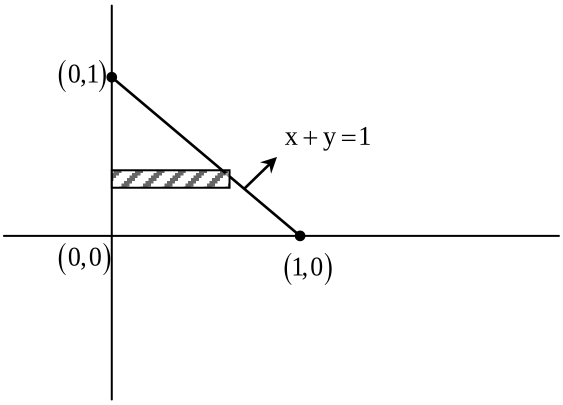
Exp: $x = 0$ to $x = 1 - y$

&

$y = 0$ to $y = 1$

By Green's theorem, $\int_C \left(3x - 8y^2\right)dx + \left(4y - 6xy\right)dy$

$$= \iint \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right)dxdy$$



$$= \int_{y=0}^{1}\int_{x=0}^{1-y}\left[-6y - (-16y)\right]dxdy$$

$$= \int_{y=0}^{1}\left[\int_{x=0}^{1-y} 10y\,dx\right]dy$$

$$= 10\int_{y=0}^{1} yx\Big|_0^{1-y}\,dy$$

$$= 10\int_{y=0}^{1} y\left[(1-y) - 0\right]dy = 10\left(\frac{y^2}{2} - \frac{y^3}{3}\right)\Bigg|_0^1$$

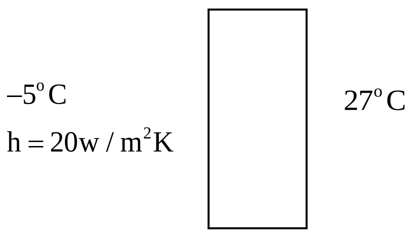
$$= 10\left(\frac{1}{3} - \frac{1}{3}\right) = \frac{5}{3} = 1.66$$

30. A brick wall $\left(k = 0.9\frac{W}{m.k}\right)$ of thickness 0.18 m separates the warm air in a room from the cold ambient air. On a particular winter day, the outside air temperature is – 5°C and the room needs to be maintained at 27°C. The heat transfer coefficient associated with outside air is $20\frac{W}{m^2K'}$. Neglecting the convective resistance of the air inside the room, the heat loss, in $\left(\frac{w}{m^2}\right)$ is

(A) 88 (B) 110 (C) 128 (D) 160

Answer: (C)

Exp:

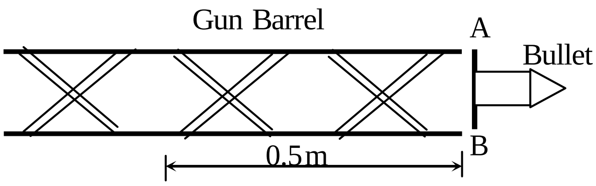


Total thermal resistance $\frac{1}{R_{th}} = \frac{1}{\frac{1}{h} + \frac{l}{k}}$

$$\frac{1}{R_{th}} = \frac{1}{\frac{1}{20} + \frac{0.18}{0.9}} = 4\ W/m^2K$$

$$Q = \frac{\Delta T}{R_{th}} = [27 - (-5)] \times 4 = 128\ W/m^2$$

31. A bullet spins as the shot is fired from a gun. For this purpose, two helical slots as shown in the figure are cut in the barrel. Projections A and B on the bullet engage in each of the slots



Helical slots are such that one turn of helix is completed over a distance of 0.5 m. If velocity of bullet when it exits the barrel is 20 m/s, its spinning speed in rad/s is _______.

Answer: 251.3

Exp: Time taken force revolution $= \frac{0.5}{20} = 0.025\text{ sec.}$

The spinning speed is $\frac{2\pi}{0.02s}$ rad/sec

$= 251.3\text{ rad/sec}$

32. Which of the following statements are TRUE, when the cavitation parameter σ = 0?

i. the local pressure is reduced to vapor pressure

ii. cavitation starts

iii. boiling of liquid starts

iv cavitation stops

(A) i, ii and iv (B) only ii and iii (C) only i and iii (D) i, ii and iii

Answer: (D)

Exp: σ = 0 implies (i), (ii) and (iii)

33. In a CNC milling operation, the tool has to machine the circular arc from point (20, 20) to (10, 10) at sequence number 5 of the CNC part program. If the center of the arc is at (20, 10) and the machine has incremental mode of defining position coordinates, the correct tool path command is (A) N 05 G 90 G01 X–10 Y–10 R10

(B) N 05 G91 G03 X–10 Y–10 R10

(C) N 05 G90 G03 X20 Y20 R10

(D) N 05 G91 G02 X20 Y20 R10

Answer: (B)

Exp: for incremental coordinates (G91) and coordinates of final point are $(-10,-10)$. The tool moves CCW (counter clockwise), So G03.

34. Ratio of solidification time of a cylindrical casting (height =radius) to the cubic casting of side two times the height of cylindrical casting is _____.

Answer: 0.5625

Exp: $t_s = k\left(\frac{V}{A}\right)^2$

for cylindrical cavity (1)

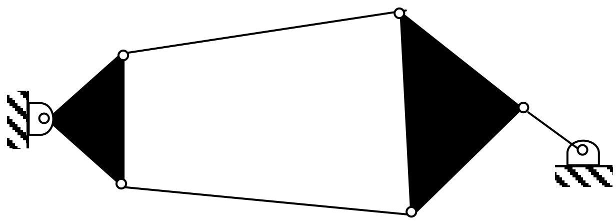
$$t_1 = k\left(\frac{\frac{\pi}{4}d^2h}{\pi dh}\right)^2 = k\left(\frac{d}{4}\right)^2 \quad (d = h)$$

for cubic casting (2)

$$t_2 = k\left(\frac{a^3}{6a^2}\right)^2 = k\left(\frac{a}{6}\right)^2 = k\left(\frac{d}{3}\right)^2 (a = 2d)$$

$$\therefore \frac{t_1}{t_2} = \frac{\left(\frac{d}{4}\right)^2}{\left(\frac{d}{3}\right)^2} = \left(\frac{3}{4}\right)^2 = 0.5625$$

35. The number of degrees of freedom of the linage shown in the figure is



(A) -3 (B) -0 (C) 1 (D) 2

Answer: (C)

Exp: Number of links, N = 6

Total number as binary joints, j = 7

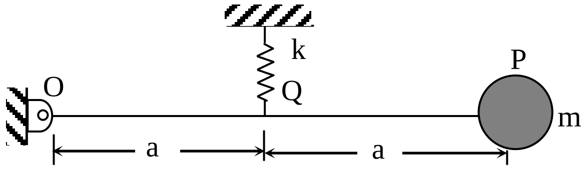
F = 3 (N-1) – 2j

= 15-14 = 1.

36. Figure shows a single degree of freedom system. The system consists of a massless rigid bar OP hinged at O and a mass m at end P. The natural frequency of vibration of the system i

(A) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{4m}}$ (B) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{2m}}$

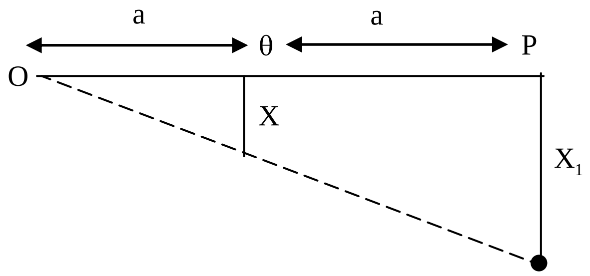
(C) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ (D) $f_n = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$



Answer: (A)

Exp: force in the spring F= 2mg [from equilibrium]

Deflection as mass at P,



$$x_1 = \frac{x}{a} \times 2a = 2x$$

$$= 2 \times \frac{2mg}{k} = \frac{4mg}{k}$$

$$w_n = \sqrt{\frac{g}{s}} = \sqrt{\frac{g}{x_1}} = \sqrt{\frac{k}{4m}};$$

$$f_n = \frac{1}{2\pi}\omega_n = \frac{1}{2\pi}\sqrt{\frac{k}{4m}}$$

37. For the linear programming problem:

Maximize $Z = 3X_1 + 2X_2$

Subject to

$-2X_1 + 3X_2 \le 9$

$X_1 - 5X_2 \ge -20$

$X_1, X_2 \ge 0$

The above problem has

(A) unbounded solution

(B) infeasible solution

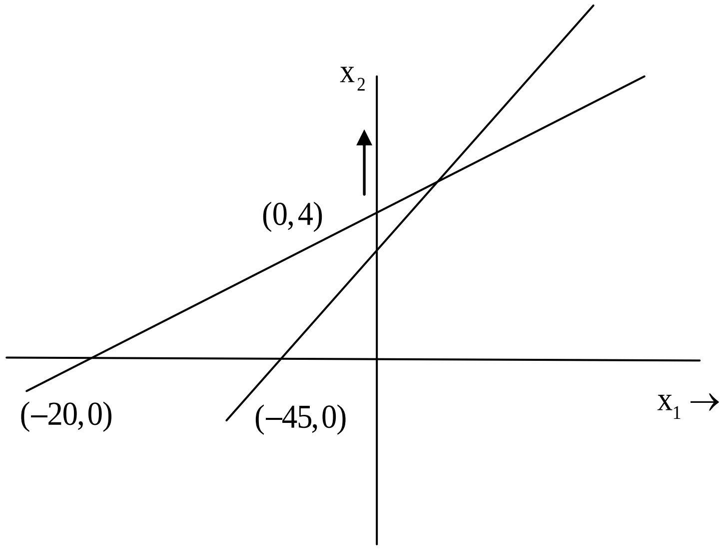
(C) alternative optimum solution

(D) degenerate solution

Answer: (A)

Exp: Plotting the graph for the given constraints as shown in figure.

From figure we can see that LPP has unbounded solution.



38. Air in a room is at 35° and 60% relative humidity (RH). The pressure in the room is 0.1 MPa. The saturation pressure of water at 35°C is 5.63 kPa. The humidity ratio of the air (in gram/kg of dry air) is ______.

Answer: 21.74

Exp: $\phi = \frac{P_w}{P_s} = 0.6 = \frac{P_w}{5.63}$

$\therefore P_w = 3.378\,\text{KPa}$

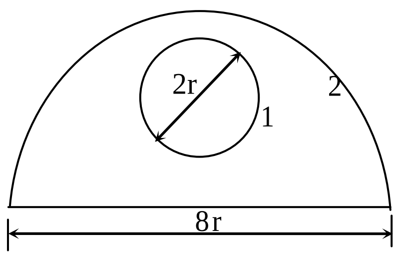
$$\text{humidity Ratio, } w = 0.622 \frac{P_w}{P_a - P_w}$$

$$= 0.622 \times \frac{3.378}{100 - 3.378}$$

$$= 0.021745\,\text{kg/kg of dry air}$$

or 21.745 g/kg of dry air

39. A solid sphere 1 of radius 'r' is placed inside a hollow, closed hemispherical surface 2 of radius '4r'. The shape factor F_{2-1} is



(A) $\frac{1}{12}$ (B) $\frac{1}{2}$ (C) 2 (D) 12

Answer: (A)

Exp: $f_{11}+f_{12}=1$

$\therefore f_{12}=1$

$f_{21}A_2=f_{12}A_1$

$$\therefore f_{21}=\frac{f_{12}A_1}{A_2}=\frac{1\times4\pi r^2}{\frac{1}{2}4\pi(4r)^2+\pi(4r)^2}=\frac{1}{12}$$

40. Newton-Raphson method is used to find the roots of the equation, $x^3+2x^2+3x-1=0$. If the initial guess is $x_0=1$, then the value of x after 2nd iteration is ___________.

Answer: 0.30

Exp: By Newton-Raphson Method,

$$1^{st}\text{ iteration, } x_1=x_0-\frac{f(x_0)}{f'(x_0)}$$

$$=1-\frac{f(1)}{f'(1)}=1-\frac{5}{10}=\frac{1}{2}$$

$$\text{Where } f(x)=x^3+2x^2+3x-1\Rightarrow f(1)=5$$

$$f'(x)=3x^2+4x+3\Rightarrow f'(1)=10$$

$$2^{nd}\text{ iteration, } x_2=x_1-\frac{f(x_1)}{f'(x_1)}$$

$$=0.5-\frac{f(0.5)}{f'(0.5)}=0.3043$$

41. The annual requirement of rivets at a ship manufacturing company is 2000 kg. The rivets are supplied in units of 1 kg costing Rs. 25 each. If the costs Rs. 100 to place an order and the annual cost of carrying one unit is 9% of its purchase cost, the cycle length of the order (in days) will be_____

Answer: 76.94

Exp: $$EOQ=\sqrt{\frac{2DC_0}{C_h}}$$

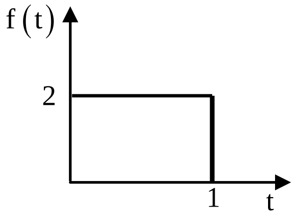
$$=\sqrt{\frac{2\times2000\times100}{0.09\times25}}=421.637$$

$$\text{length of cycle }=\frac{365}{\text{No. of orders}}=76.948\text{ days}$$

$$\text{No. of orders}=\frac{2000}{EOQ}$$

42. Laplace transform of the function f(t) is given by $F(s) = L\{f(t)\} = \int_0^\infty f(t)\, e^{-st} dt$.

Laplace transform of the function shown below is given by



(A) $\frac{1-e^{-2s}}{s}$ (B) $\frac{1-e^{-s}}{2s}$ (C) $\frac{2-2e^{-s}}{s}$

(D) $\frac{1-2e^{-s}}{s}$

Answer: (C)

Exp: $f(t) = 2; 0 < t\langle 1\rangle$

0; otherwise

$$\therefore \quad L[f(t)] = \int_0^1 2e^{-st} dt = 2\left.\frac{e^{-st}}{-s}\right|_0^1 = \frac{2-2e^{-s}}{s}$$

43. Orthogonal turning of a mild steel tube with a tool of rake angle 10° carried out at a feed of 0.14 mm/rev. If the thickness of the chip produced is 0.28 mm, the values of shear angle and shear strain will be respectively

(A) 28°20′ and 2.19 (B) 22°20′ and 3.53

(C) 24°30′ and 3.53 (D) 37°20′ and 5.19

Answer: (A)

Exp: $r = \frac{0.14}{0.28} = 0.5$

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha}$$

$\therefore \phi = 28.3345^{\circ}$

or $28^{\circ}20'$

Shear strain, $Y = \cot\phi + \tan(\phi - \alpha) = 2.1859 \approx 2.19$

44. Steam enters a turbine at 30 bar, 300°C (u = 2750 kJ/kg, h = 2993 kJ/kg) and exits the turbine as saturated liquid at 15 kPa (u = 225 kJ/kg, h = 226 kJ/kg). Heat loss to the surrounding is 50 kJ/kg of steam flowing through the turbine. Neglecting changes in kinetic energy and potential energy, the work output of the turbine (in kJ/kg of steam) is ________.

Answer: 2717

Exp: Work output $=(2993-226.50)\text{kJ / kg} = 2717$ kJ/kg

45. For a given matrix $\begin{bmatrix} 4-3i & i \\ -i & 4+3i \end{bmatrix}$, where is $i=\sqrt{-1}$, the inverse of matrix P is

(A) $\frac{1}{24}\begin{bmatrix} 4-3i & i \\ -i & 4+3i \end{bmatrix}$

(B) $\frac{1}{25}\begin{bmatrix} i & 4-3i \\ 4+3i & -i \end{bmatrix}$

(C) $\frac{1}{24}\begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$

(D) $\frac{1}{25}\begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$

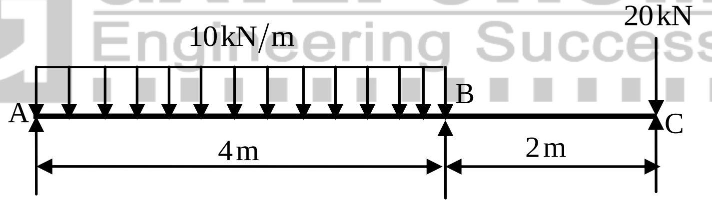
Answer: (A)

Exp: |P| = (4+3i)(4-3i)-(i)(-i) = 16+9-1 = 24

$$\text{adj}\,P = \begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$$

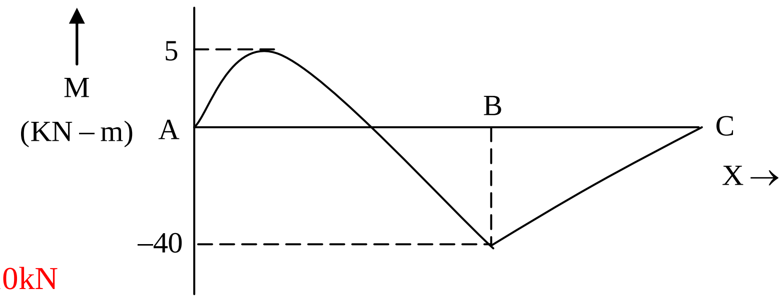
$$\therefore P^{-1} = \frac{1}{24}\begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$$

46. For the overhanging beam shown in figure, the magnitude of maximum bending moment (in kN-m) is ______.



Answer: 40 kN-m

Exp: BMD:



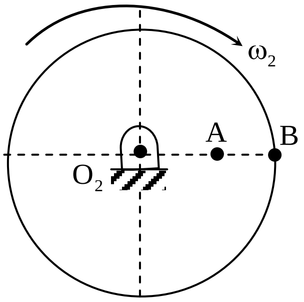
$R_A = 10kN$

$R_B = 50kN$

Maximum bending momentum occurs at reaction B an has a magnitude of 40 kN-m.

47. Figure shows a wheel rotating about O_2. Two points A and B located along the radius of wheel have speeds of 80 m/s and 140 m/s respectively. The distance between the points A and B is 300 mm. The diameter of the wheel (in mm) is ________

Answer: 1400



Exp: $V_A = 80\,m/s,\ V_B = 140\,m/s$

$r_B - r_A = 300 \quad \ldots (i)$

$\omega \times r_A = 80$

$\omega \times r_B = 140$

$\therefore \frac{r_B}{r_A} = 1.75 \quad \ldots(2)$

Solving (1) & (2), r_B=700 mm.

$\therefore$ diameter of wheel is 1400 mm.

48. The dimensions of a cylindrical side riser (height = diameter) for a 25 cm × 15 cm × 5 cm steel casting are to be determined. For the tabulated shape factor values given below, diameter of the riser (in cm) is _______.

Shape Factor	2	4	6	8	10	12
Riser Volume / Casting Volume	1.0	0.70	0.55	0.50	0.40	0.35

Answer: 10.61

Exp: $\text{Shape factor} = \frac{l+w}{h} = \frac{25+15}{5} = 8$ then from the table

$\therefore \frac{V_r}{V_c} = 0.5$

$V_r = 0.5 \times 25 \times 15 \times 5 = 937.5$

$\frac{\pi}{4} d^3 = 937.5\,cm^3$

$\therefore d = 10.61\,cm$

49. A Prandtl tube (Pitot-static tube with C = 1) is used to measure the velocity of water. The differential manometer reading is 10 mm of liquid column with a relative density of 10. Assuming g = 9.8 m/s^2, the velocity of water (in m/s) is _______.

Answer: 1.32

Exp: $\text{Velocity as water} = C_v\sqrt{2gh}$

C_v = 1 (Given)

$h = x\left[\frac{S_g}{S_0} - 1\right] = 0.01(10-1) = 0.09\,m$

$\therefore \text{velocity of flow} = \sqrt{2 \times 9.8 \times 0.09} = 1.328\,m/s$

50. In a rolling operation using rolls of diameter 500 mm if a 25 mm thick plate cannot be reduced to less than 20 mm in one pass, the coefficient of friction between the roll and the plate is ___________

Answer: 0.1414

Exp: $\mu = \sqrt{\dfrac{(\Delta h)_{max}}{R}}$

$(\Delta h)_{max} = 25 - 20 = 5\text{mm}$

$R = 250\,\text{mm}$

$\therefore \mu = \sqrt{\dfrac{5}{250}} = 0.1414$

51. Refrigerant vapor enters into the compressor of a standard vapor compression cycle at –10°C (h = 402 kJ/kg) and leaves the compression at 50°C(h = 432 kJ/kg). It leaves the condenser at 30°C (h = 237 kJ/kg). The COP of the cycle is ___________.

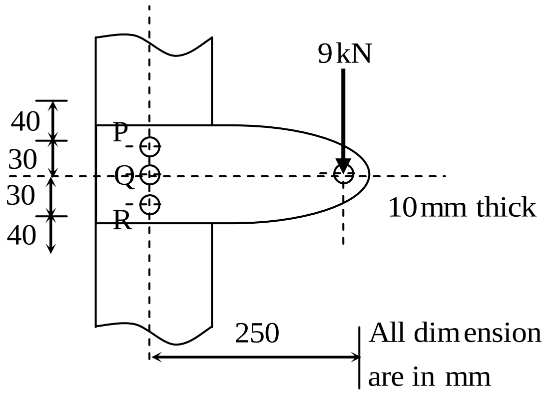
Answer: 5.5

Exp: work done=432-402=30 kJ/kg

Refrigerating effect =402-237=165 kJ/kg.

$COP = \dfrac{165}{30} = 5.5$

52. A cantilever bracket is bolted to a column using three M12 × 1.75 bolts, P, Q and R. The value of maximum shear stress developed in the bolt P (in MPa) is ________.



Answer: 341

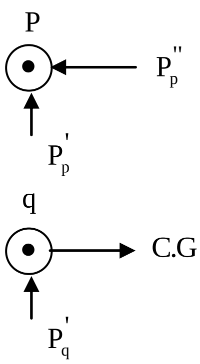
Exp: P=9kN, e=250 mm

Primary shear force

$P_p' = P_q' = P_r' = \dfrac{p}{3} = \dfrac{q}{3} = 3\text{kN}$

Secondary shear force:

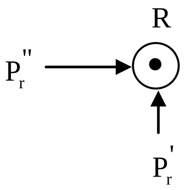
By symmetry C.G lies at the centre of bolt Q.



$$\therefore r_p = 30 \text{ mm}$$

$$r_r = 30 \text{ mm}$$

$$r_q = 0$$



$$C = \frac{Pe}{r_q^2 + r_q^2 + r_r^2} = \frac{9000 \times 250}{30^2 + 0^2 + 30^2} = 1250$$

$$P_p'' = P_r'' = C$$

$$P_p'' = Cr_p = 37.5 \text{ kN}$$

$$P_r' = Cr_r = 37.5 \text{ kN}$$

$$P_q'' = 0$$

Resultant shear force

Due to symmetry stress in P Q R will be equal in magnitude

$$P_p = P_r = \sqrt{(3)^2 + (37.5)^2} = 38.5648 \text{ kN}$$

$$\tau = \frac{P}{A} = \frac{38.5648}{\frac{\pi}{4}(0.012)^2} = 340.987 \text{ MPa} \simeq 341 \text{ MPa}$$

53. A mixture of ideal gases has the following composition by mass:

N2	O2	CO2
60%	30%	10%

If the Universal gas constant is 8314 J/mol-K, the characteristic gas constant of the mixture (inJ/kg.K) is _________.

Answer: 274.99

Exp: gas constant of mixture, $R_m = \dfrac{\text{Universal gas constant}}{\text{Average molar mass}}$

$$\text{Average molar mass } = \frac{100}{\frac{60}{28} + \frac{30}{32} + \frac{10}{44}} = 30.233 \text{ kg / kmol}$$

$$R_m = \frac{8314}{30.233} = 274.996 \text{ J / kg} - \text{K}$$

54. A shaft of length 90 mm has a tapered portion of length 55 mm. The diameter of the taper is 80 mm at one end and 65 mm at the other. If the taper is made by tailstock set over method, the taper angle and the set over respectively are

(A) 15°32′ and 12.16 mm (B) 15°32′ and 15.66 mm
(C) 11°22′ and 10.26 mm (D) 10°32′ and 14.46 mm

Answer: (A)

Exp: Rate of taper, $T = \frac{80-65}{55} = 0.27$

$$\text{Set over} = \frac{T \times L}{2} = \frac{0.27 \times 90}{2} = 12.15$$

$$\text{Taper angle} = \text{Tan}^{-1}(0.27) = 15.10$$

55. One side of a wall is maintained at 400 K and the other at 300 K. The rate of heat transfer through the wall is 1000 W and the surrounding temperature is 25°C. Assuming no generation of heat within the wall, the irreversibility (in W) due to heat transfer through the wall is ________.

Answer: 248.33

Exp: Q = 1000W

$$T_\infty = 25 + 273 = 298$$

$$Q\left[1-\frac{T_\infty}{T_1}\right] - Q\left[1-\frac{T_\infty}{T_2}\right] - Q_{ir} = 0$$

$$1000\left[1-\frac{298}{400}\right] - 1000\left[1-\frac{298}{300}\right] - Q_{ir} = 0$$

$$Q_{ir} = 248.33W$$